

cases were severe and had typical symptoms of that disease, and in no case was the *Monilia psilosis* isolated. The complement-fixation test in all these cases was negative, with the exception of one faintly positive.

Guinea-pig serum of an animal which had been inoculated with a killed culture of *Monilia psilosis* gave a strong positive reaction.

It is of interest to note that the serum from animals which had been inoculated with live cultures or killed cultures of *Monilia psilosis* gave the same results as the serum of patients that have sprue, and from which the *Monilia psilosis* had been isolated from tongue and feces. In view of these results and with Ashford's clinical and mycological work it is strongly evident that the *Monilia psilosis* of Ashford is the etiological factor in sprue. At the present time tests are being made daily in this laboratory, with the same constant results as described in this article.

THE DISINFECTION OF DRINKING WATER.

By H. D. DAKIN, D.Sc., F.R.S.,

NEW YORK,

AND

E. K. DUNHAM, M.D.,

NEW YORK.

(From the Herter Laboratory, New York.)

THE sterilization of contaminated drinking water is a problem of special importance in war time. The use of bleaching powder, or similar hypochlorite or chlorin preparation, has been used with the greatest success for the sterilization of relatively large volumes of water. The use of water carts containing water treated with a carefully regulated quantity of bleaching powder has given every satisfaction when the method could be satisfactorily carried out, as, for example, when troops are practically stationary. The problem of sterilizing small individual quantities of water, such as are needed by cavalry or rapidly moving troops, is a much more difficult problem which, up to the present, has not been perfectly solved. The use of hypochlorites for such purposes is difficult, owing to the instability of small tablets containing the minute quantity of active disinfectant. In their place, acid sulphates of the alkali metals have been extensively used in tablet form, but the superior potency of many chlorin compounds would indicate that a stable potable chlorin disinfectant suitable for the sterilization of small quantities of water was desirable. With this end in view we have made a number of experiments with various types of substances, one of which we believe to be worth practical application.

TABLE I.—EXPERIMENTS WITH P-SULPHONDICHLORAMINOBENZOIC ACID IN TABLET FORM.

No.	Water treated.	Concentration of disinfectant.	Time of action, min.	Surviving organisms, per c.c.	Tablet dissolved, min.
1	Croton water + B. coli	1 to 200,000	30	63,800	4
2	Croton water + B. coli	1 to 200,000	30	38,029	9
3	Croton water + B. coli	1 to 200,000	15	112,525	9
4	Croton water + B. coli	1 to 250,000	15	112,525	9
5	Croton water + B. coli	1 to 400,000	15	112,525	10
6	Croton water + B. coli	1 to 500,000	15	178,528	10
		1 to 500,000	30	987	10
7	Croton water + B. coli	1 to 500,000	15	125,420	12
		1 to 500,000	30	406	12
8	Croton water + 5 per cent. sewage + B. coli	1 to 175,000	15	1,119,000	9
			30	6,000	9
			60	0	9
9	Croton water + 5 per cent. sewage + B. coli	1 to 330,000	15	1,158,500	7
		1 to 330,000	30	120,061	7
		1 to 330,000	60	9,146	7
10	Croton water + 5 per cent. sewage + B. coli	1 to 500,000	15	1,120,000	5
		1 to 500,000	30	284,800	5
		1 to 500,000	60	49,318	5
				70	5
11	Deep yellow polluted river water, B. coli	1 to 250,000	20	33,152	13
		1 to 250,000	40	10,940	
		1 to 250,000	60	852	
				0	
12	Croton water, B. typhosus	1 to 225,000	20	155,400	17
				0	
13	Hard water + B. typhosus	1 to 333,333	20	85,400	14
				0	
14	Croton water, 5 per cent. sewage + B. typhosus	1 to 333,333	20	66,017	14
		1 to 333,333	40	242	
				0	
15	Croton water, 5 per cent. sewage + B. typhosus	1 to 225,000	20	240,000	14
		1 to 225,000	40	13	
				0	
16	Croton water, B. paratyphosus A	1 to 225,000	20	112,000	17
				0	
17	Croton water, 5 per cent. sewage, B. paratyphosus A	1 to 225,000	20	138,000	13
				0	
18	Croton water, 5 per cent. sewage, B. paratyphosus A	1 to 333,333	20	29,400	12
		1 to 333,333	40	15	
				0	
19	Croton water, B. paratyphosus B	1 to 225,000	20	322,500	17
		1 to 225,000	40	10	
				0	
20	Croton water, 5 per cent. sewage, B. paratyphosus B	1 to 225,000	20	309,120	13
		1 to 225,000	40	305	
				0	

TABLE I.—EXPERIMENTS WITH P-SULPHONDICHLORAMINO BENZOIC ACID IN TABLET FORM.— *Continued.*

No.	Water treated.	Concentration of disinfectant.	Time of action, min.	Surviving organisms, per c.c.	Tablet dissolved, min.
21	Croton water, 5 per cent. sewage, <i>B. paratyphosus</i> B	0	..	139,776	
		1 to 333,333	20	290	12
		1 to 333,333	40	0	
22	Croton water + <i>V. cholerae</i>	0	..	13,706	
		1 to 400,000	20	0	12½
		1 to 333,333	20	0	
23	Croton water, 5 per cent. sewage, <i>V. cholerae</i>	0	..	11,170	13
		1 to 333,333	20	0	
		1 to 333,333	20	0	
24	Croton water, <i>B. dysenteriae</i> (Flexner)	0	..	66,998	
		1 to 450,000	15	25	13
		1 to 450,000	30	0	
25	Croton water, <i>B. dysenteriae</i> (Flexner)	0	..	98,990	
		1 to 333,333	20	17,363	7
		1 to 333,333	40	58	
26	Croton water, 5 per cent. sewage, <i>B. dysenteriae</i> (Flexner)	0	..	161,861	
		1 to 333,333	20	38	13
		1 to 333,333	40	0	
27	Croton water, <i>B. dysenteriae</i> (Shiga)	0	..	33,852	
		1 to 450,000	15	12,227	6
		1 to 450,000	30	1,080	
28	Croton water, <i>B. dysenteriae</i> (Shiga)	0	..	31,200	
		1 to 333,333	20	10,934	11
		1 to 333,333	40	0	
29	Croton water, 5 per cent. sewage, <i>B. dysenteriae</i> (Shiga)	0	..	2,108	
		1 to 333,333	20	0	13
		1 to 333,333	20	0	

Our first experiments were made with chloramin-T,¹ but it was found that when this substance was added to heavily contaminated waters it required a relatively high concentration to sterilize the water promptly, particularly in the case of hard alkaline waters. For example, 1 part of chloramin-T to 25,000 parts of water may be necessary, and such an amount is decidedly unpalatable. Subsequently, it was found that much lower concentrations of chloramin-T were effective if the contaminated water was slightly acidified with any acid, *e. g.*, citric, tartaric, acetic, etc. Under these conditions, 1 to 250,000 or less of chloramin-T was effective (see Table III), and the resulting water was not unpleasant to the taste. But chloramin-T could not be made up in a tablet with the addition of an acid without decomposition, and the two-tablet system was regarded as impracticable.

Subsequently, we experimented with preformed toluenesulphondichloramins, since a substance of this type is formed on adding acid to chloramin-T. The early results were most encouraging (see Table II), and it was not until we had the product put up in tablet form that we found it to be unsuitable. The difficulties were twofold: (1) When the small necessary quantity of dichloramin

¹ The abbreviated name for sodium toluene-p-sulphochloramide, Cf. British Med. Jour., January 29, 1916. Proc. Roy. Soc., B., 1916, lxxxix, 232.

(0.002 gm. for 0.5 liter of water) was mixed with what were assumed to be inert salts, *e. g.*, sodium chloride, for making into small tablets the very slow normal rate of decomposition of the dichloramin was greatly accelerated. (2) The dichloramin, after dispensing in tablet form, became too insoluble to effect prompt sterilization. The substance had therefore to be abandoned and we turned our attention to a search for similarly active compounds which would show greater stability and solubility.

TABLE II.—EXPERIMENTS WITH O- AND P-TOLUENESULPHON-DICHLORAMIN IN POWDER AND TABLET FORM.

No.	Water treated.	Concentration of disinfectant.	Time of action, min.	Surviving organisms per c.c.	Form of disinfectant.
1	Croton water + <i>B. coli</i>	..	..	11,520	
		1 to 250,000	7	680	<i>o</i> , powder.
2	Croton water + <i>B. coli</i>	1 to 250,000	15	0	
		..	..	40,980	
		1 to 250,000	7	20	<i>o</i> , powder.
		1 to 250,000	15	4	<i>o</i> , powder.
3	Hard water + feces, suspension	1 to 250,000	30	0	<i>o</i> , powder.
		..	..	22,080	
		1 to 250,000	7	200	<i>o</i> , powder.
		1 to 250,000	15	0	<i>o</i> , powder.
4	Hard water + 10 per cent. city sewage	..	..	61,000	
		1 to 250,000	7	448	
		..	15	210	
		..	30	74	
5	Croton water + 2.5 per cent. city sewage	..	60	2	
		..	..	6,420	
		1 to 250,000	7	0	<i>o</i> , powder.
		..	..	18,300	<i>p</i> , powder.
6	Croton water + 5 per cent. sewage	1 to 250,000	7	1,611	
		1 to 250,000	15	455	
		1 to 250,000	30	0	
		..	..	18,300	<i>p</i> , powder.
7	Croton water + 5 per cent. sewage	1 to 500,000	7	11,928	
		..	15	2,600	
		..	30	930	
		..	60	0	
8	Croton water + 5 per cent. sewage	..	..	18,300	
		1 to 1,000,000	7	10,405	<i>p</i> , powder.
		1 to 1,000,000	15	18,920	
		1 to 1,000,000	30	7,024	
9	Hard water + <i>B. coli</i>	1 to 1,000,000	60	630	
		..	..	101,000	
		1 to 200,000	10	166,400	<i>p</i> , tablet.
		1 to 200,000	40	105,288	
		1 to 200,000	60	50,160	

The substance which is the most suitable that we have yet found is *p*-sulphondichloraminobenzoic acid, $C_7H_4Cl_2N_2O_2S.COOH$. It is easily prepared from cheap, readily available materials, and appears to be effective and reasonably stable. The presence of the $COOH$ group confers a slightly greater degree of solubility

in water, which is increased by dispensing it with alkaline salts such as sodium carbonate or bicarbonate, borax or sodium phosphate. Formule for the tablets are appended, together with details of the preparation of the substance and an estimate of its cost.

TABLE III.—EXPERIMENTS WITH CHLORAMIN-T, WITH AND WITHOUT ADDITION OF TARTARIC OR CITRIC ACID.

No.	Water treated.	Concentration of disinfectant.	Acid added, gm. per liter.	Time of action, min.	Surviving organisms per c.c.
1	Hard water + <i>B. coli</i>	1 to 25,000	None	10	2,508,800
		1 to 25,000	None	30	35,200
		1 to 25,000	None	30	14,880
2	Hard water + <i>B. coli</i>	1 to 300,000	0.4	10	1,120,000
		1 to 300,000	0.4	30	180
		1 to 300,000	0.4	30	0
3	Hard water + <i>B. coli</i> + 0.1 per cent. feces	1 to 200,000	0.8	10	3,232,000
		1 to 200,000	0.8	10	0
		1 to 200,000	0.8	10	0
4	Hard water + <i>B. coli</i>	1 to 250,000	0.2	10	520,000
		1 to 250,000	0.2	10	27,200
		1 to 250,000	0.2	30	7,200
		1 to 250,000	0.8	10	130
		1 to 250,000	0.8	30	50
5	Hard water + <i>V. cholerae</i>	1 to 250,000	0.8	10	711,000
		1 to 250,000	0.8	10	0
		1 to 500,000	0.8	10	0
6	Hard water + <i>B. typhosus</i>	1 to 500,000	0.8	10	315,000
		1 to 500,000	0.8	10	1,760
		1 to 500,000	0.8	30	0

Since the systematic name of the disinfectant is inconveniently long for ordinary use we propose to apply the name halazone to the tablets containing it. This abbreviated name gives some indication of the character of the compound.

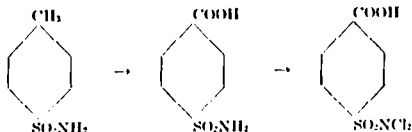
In Table I are given some of our bacteriological results. The technic employed was that in general use, and requires no special description. Five to ten standard drops of the treated water were generally used for plating on agar and counting the surviving organisms. Suitable controls were invariably carried out.

From the results in Table I it appears that a concentration of 1 to 300,000 is sufficient to sterilize an ordinarily heavily contaminated water in about thirty minutes. Such a concentration could be relied upon to remove coli, typhoid, or cholera organisms. Special experiments showed that the substance in tablet form was efficacious when acting on water contained in aluminum bottles, although a very trifling action on the metal may be observed if tablets are allowed to remain undisturbed in long contact with the metal. We believe such action to be of no practical moment. The concentration of the disinfectant given above is just perceptible to the taste, especially in warm waters containing little organic matter; but the water is perfectly palatable.

The point of advantage of the present disinfectant over most hypochlorite preparations is the fact that the active chlorin is less rapidly used up, so that the process of disinfection continues for a longer period.

Preparation of p-Sulphondichloraminobenzoic Acid. The starting-point in the preparation of this substance is p-toluenesulphonamide, a product which is readily obtained by the action of ammonia on p-toluenesulphonic chloride. The latter substance is a very cheap waste product in the manufacture of saccharin, and is available in relatively large quantities. It is now used for the manufacture of chloramin-T.

Toluenesulphonamide is oxidized to p-sulphonamidobenzoic acid, and the latter substance on treatment with chlorin under suitable conditions gives the desired dichloraminoacid. The reaction may be expressed as follows:



The experimental details are as follows:

Preparation of p-Sulphonamidobenzoic Acid. Add 250 grams commercial sodium dichromate to a mixture of 200 c.c. concentrated sulphuric acid and 600 c.c. water contained in a 2-liter round flask. Then add 100 grams crude toluene-p-sulphonamide and heat on a sand-bath with reflux condenser for one hour, using a small flame at first, as the reaction is vigorous. On cooling, wash the separated crystals well with cold water and then dissolve them in hot dilute sodium hydroxide in slight excess. Filter hot and add excess of hydrochloric acid, and when cold filter off the precipitated acid and wash well with water and dry. The yield is about 80 per cent. of theory. (Cf. Remsen: *Ann.*, 1875, clxxviii, 298.)

Preparation of p-Sulphondichloraminobenzoic Acid. Twenty grams of p-sulphonamidobenzoic acid are dissolved in 200 c.c. approximately normal sodium hydroxide (2 molecules), warming if necessary. About 200 grams of crushed ice is then added and the mixture saturated with a rapid current of chlorin. The reaction is most conveniently carried out in a fairly wide-mouthed flask, which may be shaken while the gas is being introduced. If the temperature should rise materially more ice can be added. A white, rather chalky precipitate of the dichloraminoacid is at once precipitated. The acid is filtered off, using suction, well washed with cold water, and dried *in vacuo* on a porous plate. The dry substance is practically pure, and may be powdered and preserved

apparently indefinitely. Prepared by this method the yield of the dichloraminoacid is practically the theoretical amount (26.86 grams).

The substance is sparingly soluble in water and in chloroform and insoluble in petroleum. It readily dissolves in glacial acetic acid, crystallizing in stout prisms, which melt at 213° C. The substance explodes feebly when rapidly heated on platinum foil, but, compared with most members of the group, is remarkably stable.

The purity of the compound may be checked by titration as follows: 0.1 gm. is weighed out, dissolved in glacial acetic acid and potassium iodide added. The liberated iodine is titrated with decinormal sodium thiosulphate, of which 11.8 to 14.9 c.c. will be required.

The dichloraminoacid dissolves, apparently without change, in excess of cold sodium hydrate solution, and may be reprecipitated on addition of acids. With smaller quantities of sodium hydroxide or with feebly alkaline salts, such as phosphates or borates, hydrolysis occurs with liberation of disagreeably smelling compounds of nitrogen and chlorine.

Preparation of Tablets. We have observed no very marked differences in the behavior of the sulphondichloraminobenzoic acid when made into a tablet with salt and either sodium carbonate or bicarbonate, dry or crystallized borax, or sodium phosphate, although the crystallized or hygroscopic salts are undesirable if the tablets are exposed to high temperatures. The sodium carbonate or dry borax tablets seem as satisfactory as any, and a convenient formula for tablets weighing 100 to 105 mg. is to use sulphondichloraminobenzoic acid 4 per cent, dry, sodium carbonate 4 per cent. (or dried borax 10 per cent), sodium chloride (pure) 92 per cent. The acid should be ground up with the dry salt and the sodium bicarbonate added subsequently. The mixture may be passed through a 40-mesh sieve. No lubricant or other addition is necessary, and should be avoided. The strength of the tablets should be tested by dissolving in acetic acid and potassium iodide solution and titrating with sodium thiosulphate as already described (1 c.c. $\frac{N}{10}$ thiosulphate = 0.00675 gm. of the dichloramino acid). They must not be allowed to dissolve in water and subsequently titrated, as then decomposition occurs. The tablets should be stored in small amber glass bottles.

Tablets so prepared, of the weight mentioned, contain about 4 mg. of the disinfectant, and are suitable for the sterilization of 1 liter or 1 quart of reasonably heavily contaminated water. In the case of extreme contamination a second tablet may be necessary.

Stability of Tablets. The practical success of the disinfectant we propose will depend very largely on the stability of the tablet. At present, sufficient time has not elapsed for entirely convincing

experiments, but it appears, as judged by a very few months' observation, that the stability of the tablets is great enough so as not to destroy their practical value. They are certainly more stable than other similar compounds with which we are acquainted. When kept in amber bottles under ordinary conditions no decomposition was noted in two months. When exposed to bright sunlight, in clear glass tubes, decomposition was more marked, and the same was true of the crystalized borax tablet at a temperature of 38° C. The dried borax and sodium carbonate preparations were stable under these conditions, the bicarbonate ones less so. On the whole the dry borax or dry sodium carbonate tablets appear preferable.

Cost. It is rather difficult to give precise estimates of the cost of the finished product, but it could doubtless be supplied at such a figure that 100 gallons of water could be sterilized at a cost of two cents; the cost of manufacture should not greatly exceed that of chloramin-T, which is manufactured and sold retail at \$3 per pound in England and about \$4 per pound in the United States. At this figure the cost of the disinfectant for 1,000,000 pints of water would be in the neighborhood of \$12 to \$16. No allowance is made in this calculation for the cost of tablet manufacture, but this would be a small item.

CONCERNING THE INDICATIONS FOR AND DANGERS OF TONSILLECTOMY.

BY GEORGE B. WOOD, M.D.,
PHILADELPHIA.

THE operation of tonsillectomy has become a well-recognized and perfectly justifiable procedure; indeed, it is now one of the most, if not the most, frequently done surgical operation. Not only does it constitute the bulk of the operative work of the nose and throat specialist, but large numbers of tonsils are removed by surgeons and general practitioners. It is true that in a great many cases the operation is easy, presents no special difficulty, and is not followed by any serious disturbances. Yet, on the other hand, it is not free from danger by any means, and even death, as a direct result of the operation, is entirely possible, and in fact many such deaths have occurred. We must admit, however, that the percentage of fatal results is exceedingly small when we consider the enormous number of these operations that are done throughout the country. Other more or less serious complications are more frequent, so that while the benefit that frequently accrues from the removal of an infecting tonsil distinctly outweighs the risk of the operation, it is essential to have a clear understanding of the indications and dangers before submitting any patient to this risk.